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STUDIES ON AUSTRALIAN CAINOZOIC BRACHIOPODS

2. The Family Laqueidae (Terebratellidae)

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Abstract: The genera *Frenulina* and *Aldingia* are reviewed and a new genus *Paraldingia* described. The presence of dental plates and similarities in loop structure and cardinalia indicate that these genera are related to *Kingena* and to *Laqueus*. Since it holds precedence over the Kingenidae and the Frenulininae, all these genera are referred to the family Laqueidae.

INTRODUCTION

As a result of a study of the loop development of *Frenulina sanguinolenta* (Gmelin) and of the attribution of the Miocene species *Terebratella pumila* Tate to *Frenulina* a morphological pattern is apparent which indicates relationship with *Aldingia*, with *Kingena* and with *Laqueus*. Similarities in both the loop and cardinalia thus embrace genera at present distributed between four different families, the Dallinidae (*Frenulina*), Kingenidae (*Kingena*), Kraussinidae (*Aldingia*) and Laqueidae (*Laqueus*). *Aldingia* has been assigned incorrectly to the Kraussinidae but it is considered that the families Kingenidae and Laqueidae and the subfamily Frenulininae are synonymous. Therefore it is proposed that *Aldingia, Frenulina, Kingena, Laqueus* together with related genera be placed in the Laqueidae. Their familial position will be discussed in greater detail in a subsequent paper on terebratellacean loop development.

Family Laqueidae Thomson 1927

Owen (1970) proposed the separation of three Mesozoic genera, *Kingena, Zittelina, Belothyris,* from the main family Dallinidae. He suggested that structures of the loop in these genera 'the double attachment of brachial branches to septum and the expanded transverse band' (p. 49) warranted the elevation of Elliott's Kingeninae to family status. On this basis *Aldingia* and *Paraldingia* gen. nov. should be included in the Kingenidae: both possess a loop with two pairs of connecting bands attached to the septum and transverse bands with postero-lateral expansions. In addition these genera, like *Kingena*, display dental plates and a hinge platform with a posterior striated or roughened area in place of the usual cardinal process. A particularly close resemblance is apparent between *Kingena mesembrina* (Etheridge) from Upper Cretaceous beds of Western Australia and *Paraldingia woodsii* (Tate) from Lower Miocene beds of Tasmania (Pl. 6, fig. 1-6).

From the accompanying study of the loop development of *Frenulina sanguinolenta* it may be seen that the penultimate growth stage of this species is the same pattern as that observed in adult specimens of *Kingena* (Pl. 6, fig. 1-3), *Aldingia* (Pl. 5, fig. 11-12) and *Paraldingia* (Pl. 6, fig. 4-6). In all these genera the loop displays two pairs of connecting bands, the lateral and the vertical. The vertical connecting bands run from the septum to the transverse band and are defined as medio-vertical connecting bands in the accompanying paper on the loop development of *F. sanguinolenta*. In *Kingena, Aldingia* and *Paraldingia* these bands are reduced in width in such a manner that they retain their connection with the median septum. In *F. sanguinolenta*, on the other hand, the reduction in width of the vertical connecting bands occurs simultaneously with their change in position. It is suggested that these differences may be accounted for by the differential erosion of the free borders of the vertical connecting bands; in *Kingena* and *Aldingia* there is greater resorption laterally than medially, the reverse being the case in *F. sanguinolenta*. In adult *F. sanguinolenta* these bands retain their ventral connection with the transverse band but their dorsal attachments lose their connection with the septum and lie across the lines of union of the lateral connecting bands and the descending branches. In this position the bands are defined as latero-vertical connecting bands which are present, with

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the lateral connecting bands, in the adult loop of *Laqueus* which differs from that of *F. sanguinolenta* only in possessing thinner bands.

The penultimate stage of the loop of *Frenulina sanguinolenta* had not been described in the only previous account of its development, that of Deslongchamps (1884). A study of the loop development of *Laqueus californianus* (Koch) by Konjoukova (1957) also omits the growth stages between the first appearance of the lacunae in the ring and the definitive adult pattern. Elliott (1953) however comments: 'Young adult *Frenulina sanguinolenta* illustrate how closely this process is to laqueiniform development. In this way the distinctive kingeniform loop was produced, with connecting bands from descending branches to septum' (p. 267). Owen (1970) has also noted that the adult loop of *Waconella* is the same as *Laqueus* and that young adult examples of *Waconella* display the adult loop pattern of *Frenulina* and claims that 'the Recent genera *Frenulina* and *Laqueus* have a similar loop development to that of *Kingena* and *Zittelina*' (p. 44).

Hence the adult loop structure of *Kingena, Belothyris, Zittelina, Aldingia* and *Paraldingia* is seen in a late growth stage of *F. sanguinolenta* whose adult pattern is characteristic of *Laqueus* and *Waconella*. With respect to cardinalia pattern all these genera except *Frenulina* display a hinge platform formed by the fusion of socket ridges, crural bases and hinge plates; no separate cardinal process is present. *F. sanguinolenta* is characterized by discrete inner hinge plates with free anterior and medial borders and a small transverse cardinal process. These apparently disparate patterns of cardinalia are linked by variants of *Frenulina pumila* (Tate). The adult loop of *F. pumila* is identical with that of *F. sanguinolenta* and the cardinalia pattern is common to some members of both species. The only method by which they may be separated is that they display different ranges of variation in external features (see this paper p. 119) and internally in the disposition of the hinge plates. The normal condition of the hinge plates in *F. sanguinolenta* is described above and there is little variation from this norm. On the other hand *F. pumila* shows considerable variation in the disposition of the hinge plates. They may be discrete as in *F. sanguinolenta*, they may be fused medially thus presenting the appearance of an excavate shelf, or their medial borders may fuse with the valve floor on either side of the median septum. All variants between these three main patterns are available. In displaying a wide range of variability in hinge plate pattern *F. pumila* provides links with other genera. Those specimens of *F. pumila* in which the hinge plates are fused medially to form an excavate shelf bear a marked similarity to members of *Paraldingia*, particularly to *P. woodsii*. In neither species does the anterior border of the hinge plates fuse with the underlying septum (although fusion may occur near the posterior limits of each structure), a feature unique to these two species. In *F. pumila* a small cardinal process is present, in *P. woodsii* only its posterior surface is apparent as a striated area of the hinge platform. If one compares the illustrations of *Frenulina pumila* and *Paraldingia woodsii* in Pl. 5, fig. 7 and Pl. 6, fig. 4 it is not difficult to visualize how a small cardinal process could be incorporated in the hinge platform or alternatively how an area specialized for muscle attachment could be elevated by thickening from the hinge platform surface. A pattern similar to that of *P. woodsii* is evident in the cardinalia of *Laqueus* and *Kingena*, neither genera displaying a separate cardinal process. In *Kingena* the hinge plates and associated structures are free of the valve floor anteriorly but posteriorly are fused with the floor as a result of secondary thickening in the area; in *Laqueus* the hinge plates are excavate for their full length and are fused anteriorly on top of the septum. Thus from the variations exhibited by *Frenulina pumila* it may be seen how a relationship exists between the cardinalia patterns of *Frenulina, Paraldingia, Kingena* and *Laqueus*.

In brief then, the genera discussed above display two loop patterns both of which are seen in the ontogeny of one of these genera *Frenulina*. *Frenulina* also provides, in the variants of one of its species, the two patterns of cardinalia which may be associated with either loop pattern. Thus these genera appear to show random variation in two loop and two cardinalia patterns. All these genera possess dental plates and display rectimarginate to sulcate folding and it is felt that their separation into four different families cannot be justified. Therefore it is recommended that the Laqueidae includes *Aldingia, Paraldingia*, all members of the Kingenidae attributed to this family by Owen (1970) and, from the subfamily Frenulininae, *Frenulina* and *Jolonica*. The remaining member of the Frenulininae, *Kamoica*, is not well-documented; the loop is unknown and Hatai (1940) states that the cardinalia resemble *Pictothyris*, a genus placed by him (1965) in the Laqueidae. However, the Cainozoic Pacific genus *Jolonica* can be placed in the Laqueidae with some confidence since Cooper (1957) made available an excellent set of photographs of this previously unillustrated type species. *Jolonica* is characterized by free inner hinge plates with a

small cardinal process and a loop with wide mediovertical connecting bands. That is, *Jolonica* combines the cardinalia of *F. sanguinolenta* with the loop pattern of *Kingena* and *Paraldingia*. In addition the dental plates characteristic of other members of the family are present.

The addition of *Kingena, Zittelina, Belothyris, Frenulina, Jolonica, Aldingia* and *Paraldingia* to the Laqueidae extends the range of the family from the Upper Jurassic through Tertiary to Recent times. Sufficient extra-Australian forms have not been seen to pronounce on evolutionary trends, but there is a fairly obvious line of succession apparent in the Australian material observed. The Cretaceous species *Kingena mesembrina* (the only species previously described from Australia) seems to be related to the Recent Pacific *Frenulina sanguinolenta* through the Lower Miocene *Paraldingia woodsii* and the Upper Miocene-Pliocene species *Frenulina pumila*. No representatives of this family have been described from either New Zealand or Patagonia.

Family Laqueidae Thomson, 1927
Genus **Frenulina** Dall 1894

Frenulina Dall 1894, *Proc. U.S. natn. Mus.* 17:724.
Frenulina Thomson 1927, *N.Z. Board Sci. & Art*, Manual No. 7: 241-2.
Frenulina Hatai 1936, *Venus*, Kyoto, 6 (1): 2-3.
Frenulina Hatai 1940, *Sci. Rep. Tohoku Univ.* Ser. 2, Geol. 20: 326-7.
Frenulina Hatai 1965, *Treatise on Invertebrate Paleontology*: H842.

Type Species: (Original Designation) *Anomia sanguinolenta Gmelin* 1790.

Diagnosis: Anterior commissure rectimarginate to sulcate, deltidial plates discrete to conjunct, foramen submesothyrid to mesothyrid. Cardinalia lamellar, consisting of socket ridges, crural bases, inner hinge plates with free or fused medial borders and a small transverse cardinal process. Loop with two pairs of connecting bands, lateral and latero-vertical and a transverse band with postero-lateral spines. Ventral valve with dental plates and a sessile pedicle collar.

Stratigraphic Range: Upper Miocene—Recent.

Distribution: Australia (U. Miocene); Okinawa (Pliocene-Pleistocene); Australia, Hawaiian Islands, Philippines, New Caledonia, Indian Ocean, Tonga, Tahiti, Japan, Okinawa (Recent).

Comments: The inclusion in *Frenulina* of the Miocene species *Terebratella pumila* Tate is of interest in extending the vertical distribution of the genus. *F. sanguinolenta* is one of the most widespread of Recent Pacific brachiopods. The species has also been described by Cooper (1957) from Pliocene and Pleistocene limestones of Okinawa, an attribution not included in Hatai's description (1965) of *Frenulina*.

F. sanguinolenta and *F. pumila* are closely related species and show few distinguishing features. Externally *F. sanguinolenta* is characterized by colour patterns on the valves which may have been present in *F. pumila*. In *F. sanguinolenta* the common condition of the foramen is submesothyrid with nearly conjunct deltidial plates; however the largest specimens from some localities may show a mesothyrid foramen with conjunct deltidial plates. In *F. pumila* the foramen is submesothyrid with discrete deltidial plates in all specimens examined. The internal features, the loop, cardinalia and structures of the ventral valve, are indistinguishable in many specimens. Only one feature, the disposition of the hinge plates, may differentiate the two species internally. In *F. sanguinolenta* the hinge plates show little variation and are, in the vast majority of specimens examined, quite separate from each other ('divided cardinal plate' of Hatai, 1940, p. 327) and display free anterior and medial borders. In rare instances the medial borders of the hinge plates may fuse at their posterior limits i.e. immediately underneath the cardinal process. *F. pumila*, on the other hand, shows considerable variation in the disposition of the hinge plates (Pl. 5, fig. 6-8). The specimens examined display three patterns, no one of which appeared to dominate, and a full range of variants between them. The first of these patterns is the same as that seen in *F. sanguinolenta* i.e. free hinge plates with the median septum tapering off as a low ridge between their medial borders. In the second type seen, the hinge plates are fused medially thus appearing as an excavate shelf under which the low median septum runs. The third pattern is characterized by separate hinge plates the medial borders of which are fused to the valve floor on either side of the median septum, a pattern similar to that seen in *Macandrevia cranium* (Müller).

Frenulina sanguinolenta (Gmelin 1790)

The development of the loop and cardinalia of *F. sanguinolenta* from Masthead Island, is described in an accompanying paper. The Australian specimens conform in all diagnostic features with descriptions of the species from other localities.

Occurrence: The Australian localities from which *F. sanguinolenta* has been collected are listed below. In addition localities outside Australia have been listed, if the material is in Australia and has been observed by the author. The abbreviations WAM, SAM, and NMV represent the Western Australian Museum, the South Australian Museum and the National Museum of Victoria.

South Australia: Fowlers Bay (WAM).
Western Australia: Onslow, 56 m (WAM).
Queensland: Masthead Island, 34-40 m (SAM and NMV).
New Caledonia: (SAM).
Hawaii: Waikiki, 120 m (WAM); Oahu (NMV).
Sulu Archipelago: Tangalan Island in Maluso Bay, 34 m; 1 mile and 050° from Maluso Bay, 52 m; SE. of Balabac Island, Palawan, 60 m; 8·9 miles W. of Cape Melville light, Balabac Island, Palawan, 50-56 m; N. of Siasi Island, 40-42 m; SW. of Malanipa Island, Basilan Straits, 60 m; 3 miles W. of Malanipa

Island, Basilan Straits, 26 m; 9 miles and 133° from Bongoa light, Tawitawi Bay, 26 m (WAM).
Moluccas: The Mariel King Memorial Expedition 1970 collected specimens at present in the care of the Western Australian Museum from the following stations; AM11 50 m, CP1, 28-60 m, KN11 54-92 m, KN111 74-80 m, KN1V 60-62 m, KRV1 30-40 m.

Frenulina pumila (Tate 1899)
(Pl. 5, fig. 1-8)

Terebratella pumila. Tate 1899, *Trans. R. Soc. S. Aust.* 23: 255, Pl. 8, fig. 1.

DESCRIPTION: Shell outline subcircular, unequally biconvex, the ventral valve deeper. Anterior and lateral commissures rectimarginate; cardinal margin shorter than the greatest breadth of the shell and gently curved. Deltidial plates small, discrete. Palintropes defined by subangular beak ridges. Foramen submesothyrid, large, incomplete, lined by a sessile pedicle collar. Beak short, erect.

Dorsal valve with socket ridges posteriorly fused with the borders of the valve, medially merging with the crural bases. Crural bases, thin horizontal bands linking the bases of the socket ridges with the hinge plates. Inner hinge plates lamellar, fused medially for the greater part of their length, with a wide v-shaped anterior border (see following section on variation). Cardinal process narrow, transverse with roughened posterior surface. Median septum thin, extending to an area just posterior to the mid-length of the valve, moderately high anteriorly, gradually losing height posteriorly to terminate as a low ridge on the valve floor underneath the hinge plates. Loop with descending branches with narrow anterior and posterior segments broadening medially to unite with the two pairs of connecting bands: lateral connecting bands narrow, extending from the anterior elevated tip of the septum to fuse laterally with the descending branches and the latero-vertical connecting bands; latero-vertical connecting bands broad, converging slightly posteriorly, their dorsal lines of attachment fused with both the lateral connecting bands (posteriorly) and the descending branches (anteriorly), their ventral lines of attachment fused with the inner borders of the transverse band; transverse band broad with short posteriorly directed spines projecting from its postero-lateral corners.

Ventral valve with small hinge teeth, moderately stout, triangular in outline. Dental plates lamellar, laterally delimiting a pair of cavities, medially confluent with a wide impunctate sheath, the sessile pedicle collar. Pedicle collar thin, longitudinally striated, lining and intimately fused with the posterior cavity of the valve and extending posteriorly to the borders of the foramen.

VARIATION: The external features of this species show little variation apart from slight differences in the degree of convexity of the valves and the anterior commissure which may be rectimarginate or slightly sulcate. However, there is considerable variation in the position and extent of the hinge plates. In some specimens examined the hinge plates present the same appearance as in *F. sanguinolenta*, i.e. narrow, shelf-like structures extending medially from the fused socket ridges and crural bases, with free anterior and medial borders, their posterior borders fused with the posterior wall of the valve a short distance below the cardinal process. Other specimens of *F. pumila* display medial fusion of the hinge plates so that the area bounded laterally by the combined socket ridges and crural bases and posteriorly by the posterior wall of the valve is occupied by an excavate platform widely separated anteriorly from the valve floor. In such cases the low median septum passes underneath the fused hinge plates and gradually merges with the floor of the valve, sometimes merging also with the under surfaces of the hinge plates. Variants are found which show all degrees of medial fusion of the hinge plates, this apparently taking place in a posterior to anterior direction.

In addition other specimens show fusion of the medial borders of the hinge plates with the valve floor instead of with each other. The hinge plates fuse with the valve floor on either side of the median septum thus giving the appearance of two pockets with anterior openings lying between the septum and the socket ridges.

TYPE MATERIAL: Neotype P17326 (length 10 mm, breadth 9 mm, depth 5 mm) in the Palaeontological Collection of the National Museum of Victoria.

STRATIGRAPHIC RANGE: Mitchellian-Kalimnan.

OCCURRENCE: *Tambo River Formation*: Swan Reach, Victoria.

Jemmys Point Formation: Ritchies cutting on Scrivenors Rd., W. side of Mississippi Creek, Grid Ref. Bairnsdale 878 329. W. side of N. arm, Lakes Entrance, Victoria, 0·9 m above high tide mark, Grid Ref. Bairnsdale 909 278.

COMMENTS: Tate described *F. pumila* from three specimens obtained from 'the Gippsland Lakes'. Tate states that the largest of these specimens was sacrificed to display the internal details. The two syntypes remaining are not present in Tate's collection in the South Australian Museum and are presumed to have been lost. Specimens which conform with Tate's description and his one illustration have been obtained from Swan Reach, Mississippi Creek and Jemmys Point. These localities are in the Gippsland Lakes area and it is known from Dennant (1898) that he and Tate collected at Swan Reach and at Mississippi Creek. Many specimens are available from Swan Reach, a few from the other two localities. The specimens from each locality display dental plates, a loop with two pairs of connecting bands and cardinalia with inner hinge plates and a small cardinal process; externally they agree in the possession of a submesothyrid foramen, small discrete deltidial plates and a rectimarginate anterior commissure. The specimens obtained from Mississippi Creek and Jemmys Point however differ externally from those collected at Swan Reach in the degree of convexity of the valves. The valves are fully and evenly convex in the specimens from Swan Reach, specimens from the other localities are less convex in the umbonal areas, a feature noted by Tate.

It is also noteworthy that the deposits at Mississippi

Creek and Jemmys Point are younger in age (Cheltenhamian-Kalimnan) than those at Swan Reach (Mitchellian). Therefore it is possible that two species are represented here. A range of variability in some morphological features is noted above and is based on a collection of nearly 100 specimens from Swan Reach. Only three specimens from Mississippi Creek have been examined and two from Jemmys Point, consequently there is no indication of the variability of different morphological features from these localities. The abundance of material obtainable from Swan Reach makes it desirable that this locality be selected as the type locality for the species. The largest specimen observed by Tate (5 mm in diameter) is approximately half the size of the largest specimens examined from the three localities cited above.

Aldingia Thomson 1916

Aldingia Thomson 1916, *Geol. Mag.* Dec. 6 (3): 501.
Aldingia Thomson 1927, *N.Z. Board Sci. & Art*, Manual No. 7: 230-1.
Aldingia Hatai 1965, *Treatise on Invertebrate Paleontology*: H834.
TYPE SPECIES: (Original Designation) *Terebratella furculifera* Tate 1880.
DIAGNOSIS: Anterior commissure rectimarginate to sulcate, deltidial plates discrete to conjunct, foramen submesothyrid to mesothyrid. Cardinalia thick with socket ridges flanking a solid platform fused anteriorly with the median septum, with a transversely striated area on the posterior segment of the platform serving for the attachment of the diductor muscles. Loop with two pairs of connecting bands, lateral and medio-vertical. Ventral valve with a sessile pedicle collar and hinge teeth supported by swollen bases derived from thickened dental plates.
STRATIGRAPHIC RANGE: Upper Eocene-Recent.
DISTRIBUTION: Australia.
COMMENTS: Thomson (1916, 1927) created the genus *Aldingia* for three species, *Terebratella furculifera* Tate, *Terebratella* (?) *woodsii* Tate, and *Megerlia willemoesi* Davidson, which displays loops with two pairs of connecting bands attached to the septum. *T.* (?) *woodsii* is transferred here to the new genus *Paraldingia*. Thomson referred *Aldingia* to the subfamily Mühlfeldtiinae Oehlert (embracing genera now attributed to the Kraussinidae Dall 1870) stating that the subfamily position is uncertain and that the absence of dental plates in *Aldingia* made relationship with *Frenulina* or *Laqueus* unlikely. The presence of dental plates, associated with a sessile pedicle collar, is described in those species referred to *Paraldingia*. Adult specimens of *Aldingia furculifera* display a sessile pedicle collar confluent anteriorly with swollen bases supporting the hinge teeth. No very young specimens of *A. furculifera* are available but the ventral interior of one young adult (Pl. 5, fig. 13) does indicate that these swollen bases arise as a result of the thickening of early dental plates and their subsequent fusion with the valve walls. Moreover in all specimens in the early adult size range the swollen bases supporting the hinge teeth are limited to the area immediately beneath the teeth and do not represent a generalized thickening of the lateral walls of the valve.

The species attributed to *Aldingia* and *Paraldingia* are closely related in external characters and in cardinalia and loop patterns. With respect to external characters both genera display rectimarginate to sulcate folding and a submesothyrid to mesothyrid foramen, the deltidial plates are discrete to conjunct in *Aldingia*, discrete in *Paraldingia*. The chief difference between the two genera is the degree of thickness of the elements of the loop, cardinalia and structures of the ventral valve. It is curious that *Aldingia* which displays thick, solid cardinalia possesses a thin lamellar loop while *Paraldingia* with thin lamellar cardinalia displays a loop with thicker, broader, spinous bands.

Aldingia furculifera (Tate 1880)
(Pl. 5, fig. 9-16)

Terebratella furculifera Tate 1880, *Trans. R. Soc. S. Aust.* 3: 161, Pl. 11, figs. 7a-c.
Waldheimia (?) *insolita* Tate (pars) 1880, *Ibid.*: 151-2.
Terebratella furculifera Tate 1899, *Ibid.* 23: 254-5.
Aldingia furculifera Thomson 1916, *Geol. Mag.* 53: 501.
Aldingia furculifera Thomson 1927, *N.Z. Board Sci. & Art*, Manual No. 7: 230-1, fig. 71a.
DESCRIPTION: Shell outline broadly ovate, the greatest width at mid-length; unequally biconvex, the ventral valve slightly deeper and slightly carinate, dorsal valve evenly convex. Anterior and lateral commissures rectimarginate, cardinal margin terebratulid. Deltidial plates small, discrete, separated by a narrow fissure medially. Foramen submesothyrid, incomplete with a slight notch anteriorly marking the line of separation of the deltidial plates. Beak short, nearly erect.

Dorsal valve interior with posterior region thickened to form a platform in which the sockets are countersunk laterally. Socket ridges moderately thick, straight, converging posteriorly to fuse with the valve borders, anteriorly overhanging the sockets, sloping fairly steeply downwards medially. Crural bases visible as slightly swollen areas at the bases of the medial slopes of the socket ridges and extending for approximately the anterior halves of the lengths of the socket ridges. Hinge platform solid, slightly concave; posterior region of platform delimited as transversely striated area in the shape of a quadrant of a circle, representing posterior surface of the cardinal process and serving for the attachment of the diductor muscles; immediately anterior to this area two ovate scars of the dorsal pedicle muscles are visible. Median septum moderately thick, very short, extending anteriorly for a distance approximately equal to the length of the hinge platform, tapering sharply away anteriorly. Loop with slender branches and bands; the transverse band excavated medially leaving the wide posterolateral projections. Adductor muscle impressions fairly deep, ovate scars extending from the base of the hinge platform to areas just beyond the anterior tip of the septum.

Ventral valve with thick hinge teeth under which lie grooves for the reception of socket ridges. Lateral valve walls thickened in a localized area immediately ventral to the hinge teeth and grooves. A slight ridge extends across the floor of the valve between the posterior terminations of the lateral thickened areas and marks the anterior border of the sessile pedicle collar.

TYPE MATERIAL: Eleven syntypes, T895 A-K, in the Ralph Tate Collection, South Australian Museum, of which T895H (length 14 mm, breadth 12 mm, depth 5·5 mm) is selected as the lectotype.

TYPE LOCALITY: Tortachilla Limestone, Blanche Point, South Australia.

STRATIGRAPHIC RANGE: Aldingan-Janjukian.

OCCURRENCE: *South Australia*: *Tortachilla Lime stone* (Aldingan): Blanche Point, Maslin Bay and Christie's Beach, Aldinga; Port Noarlunga. *Blanche Point Marls*: Blanche Point, Aldinga.

Western Australia: *Wilson Bluff Limestone* (Aldingan): Bunda Cliffs, Great Australian Bight.

Victoria: *Browns Creek Clay* (Aldingan): Washout 1, immediately NW. of the mount of Browns Creek, Grid Ref. Aire 277 177; Washout 11, nearest mouth of Johanna River, uppermost horizon in forked gully, Grid Ref. Aire 276 179. *Castle Cove Limestone* (Aldingan): Geological survey locality Aw5, Grid Ref. Aire 307 162. *Glen Aire Clay* (Aldingan): Geological Survey locality Aw1, outcrop nearest Point Flinders at 'waterfall', Grid Ref. Aire 368 096. *Calder River Limestone* (Janjukian): Geological Survey locality Aw4, anticline on Aire Coast, near Middle Beach, Glen Aire.

COMMENTS: *A. furculifera* was first described by Tate (1880) from six syntypes collected from the Tortachilla limestone, at Blanche Point, Aldinga. Tate's collection in the South Australian Museum includes a card bearing 11 specimens (T895A-K) and labelled *Terebratella furculifera*. The largest of these specimens (T895-H) has a length of 14 mm, breadth of 12 mm, depth of 5·5 mm and like the other syntypes displays a submesothyrid foramen and discrete deltidial plates. Internally the valves are thickened posteriorly in the hinge platform area of the dorsal valve and in the lateral walls of the ventral valve immediately underneath the hinge teeth. The remaining parts of the valves are relatively thin without noticeable muscle or pallial sinus markings.

In the same paper Tate described the species *Waldheimia* (?) *insolita* from a collection of specimens obtained from 'a marly band in Blanche Point Cliff, Aldinga'. (p. 152). A group of specimens on a card in Tate's type collection are labelled '*Waldheimia insolita*, Aldinga Bay' and are numbered T908A-E-G-H. With the exception of T908A these specimens are still regarded as members of the species *insolita* (a magadinid species). Specimen T908A differs from the remaining material externally (Pl. 5, fig. 14). in displaying a mesothyrid foramen and conjunct deltidial plates. Since the valves lie loosely one upon the other internal details could also be studied. (Pl. 5, fig. 15-16). The cardinalia bear a close resemblance to these structures in the material described by Tate as *A. furculifera* from Blanche Point; the loop is broken but the remains of two pairs of connecting bands are seen on the crest of the septum. This specimen differs from the Blanche Point syntypes of *A. furculifera* in possessing a mesothyrid foramen, conjunct deltidial plates, thick valves with prominent muscle and pallial sinus markings and in its larger size (length 28 mm, breadth 20 mm). Since both the smaller and the larger forms have been collected from the Blanche Point Marls it seems likely that the species *A. furculifera* is described from young adult forms and that specimen T908A represents the adult form. If this is so then the transition from a submesothyrid to a mesothyrid foramen and from discrete to conjunct deltidial plates occurs at a relatively late stage of development although a similar developmental pattern may be seen in other genera including *Frenulina*.

Again in 1880 Tate referred to *Waldheimia* (?) *insolita* a group of specimens (T899A-F) from Wilson's Bluff limestone, Great Australian Bight. Tate (1899, p. 254) stated that these specimens 'prove on dissection to belong to *Terebratella* and to the species *furculifera*'. Since these specimens also show conjunct deltidial plates (foramen remains submesothyrid), thicker valves, and display an average length of 23 mm it does give further weight to the attribution of T908A as the adult form of *A. furculifera* and of specimens T895A-K as a collection of young adults. Although *insolita* has page priority, under Recommendation 24A of the International Code of Zoological Nomenclature the name *furculifera* has been chosen for this species.

Aldingia willemoesi (Davidson 1878)

Megerlia willemoesi Davidson 1878, *Proc. R. Soc. Lond.* 27: 438-9.

Megerlia willemoesi Davidson 1880, *Rep. Voy. H.M.S. Challenger*, Zool. Vol. 1, Brachiopoda: 51-2, Pl. 4, figs. 1-3.

Megerlia willemoesi Davidson 1886, *Trans. Linn. Soc. Lond.* 4(2) Zool: 111, Pl. 19, figs. 23-26.

Megerlia willemoesi Tate 1886, Trans. R. Soc. S. Aust. 9: 110-1.

Aldingia willemoesi Thomson 1927, *N.Z. Board Sci. & Art*, Manual No. 7: 230-1, fig. 71b.

COMMENTS: The only specimens of *A. willemoesi* described are those collected by the Challenger Expedition at 240 metres off Twofold Bay, South Australia and one dead shell recorded by Tate from 44 m at Encounter Bay, South Australia. Davidson gave a brief diagnosis of the species in 1878 and in the Challenger Reports of 1880 printed a fuller description. From this description and the accompanying illustrations the species appears to be slightly sulcate in folding and to possess fused deltidial plates; the foraminal position and the type of cardinalia are difficult to estimate. Therefore the species is referred to *Aldingia* with some doubt. The loop, in displaying two pairs of connecting bands, lateral and medio-vertical, is typical of both *Aldingia* and *Paraldingia*.

Paraldingia gen. nov.

TYPE SPECIES: *Terebratella* (?) *woodsii* Tate 1880.

DIAGNOSIS: Anterior commissure rectimarginate to

sulcate, deltidial plates discrete, foramen submesothyrid to mesothyrid. Cardinalia lamellar with excavate, inner hinge plates fused medially and continuous posteriorly with a transversely striated area serving for the attachment for the diductor muscles. Loop with wide, lamellar ascending and descending branches, a thick transverse band with postero-lateral flanges and stout lateral and medio-vertical connecting bands. Ventral valve with dental plates and a sessile pedicle collar.

STRATIGRAPHIC RANGE: Upper Eocene—Lower Miocene.

DISTRIBUTION: Australia.

COMMENTS: The genus *Paraldingia* is erected for species which differ from *Aldingia* in the possession of discrete dental plates, excavate inner hinge plates and a loop with broad and moderately thick connecting bands. The relationships between the two genera are discussed in the comments on *Aldingia*.

The species *P. woodsii* and *P. tepperi* differ in outline, folding and foraminal position. *P. woodsii* is sub-pentagonal in outline with a sulcate anterior commissure and a submesothyrid foramen, *P. tepperi* is subcircular, rectimarginate and mesothyrid. *Terebratella pentagonalis* is provisionally referred to the genus from the external characters of a single specimen which is similar to *P. woodsii* in folding and foraminal position. The two species differ only in the degree of convexity of the valves and in folding. In *P. pentagonalis* the anterior commissure is rectimarginate and the valves show a greater degree of convexity than is the case in *P. woodsii*.

Paraldingia woodsii (Tate 1880)
(Pl. 6, fig. 4-8)

Waldheimia corioensis Tenison Woods 1877, *J. Proc. R. Soc. N.S.W.* 11: 78-9, figs. 3a-c. (non *Waldheimia corioensis* McCoy).

Terebratella (?) *woodsii* Tate 1880, *Trans. R. Soc. S. Aust.* 3: 161-2, pl. 9, figs. 10a-c.

Terebratella woodsii Tate 1899, Ibid. 23: 255.

Aldingia woodsii Thomson 1927, *N.Z. Board Sci. & Art* Manual No. 7: 231.

DESCRIPTION: Shell outline broadly subpentagonal, greatest width lying at midlength; unequally biconvex, dorsal valve slightly convex with a median sulcus gradually widening anteriorly and extending from the umbo to the anterior border of the valve, ventral valve deeper with a prominent median carina. Anterior commissure sulcate, lateral commissures sinuate; cardinal margin terebratulid. Deltidial plates discrete. Palintropes defined by subangular beak ridges. Foramen submesothyrid, incomplete, slightly marginate, lined with a sessile pedicle collar. Beak short, suberect.

Dorsal valve interior with short, straight socket ridges converging slightly posteriorly and fused with the borders of the valve, anteriorly overhanging deep sockets. Crural bases fused with the socket ridges, appearing anteriorly as slight ridges at the medial bases of the socket ridges. Hinge plates lamellar, excavate, short, fused laterally with the crural bases and sloping fairly steeply medially to fuse with each other on top of the median septum, anteriorly the hinge plates extend forwards slightly further laterally than medially; a low, longitudinal ridge extends along the mid-line of the posterior two-thirds of the length of the fused hinge plates. Posterior border of hinge plates marked by a slight subarcuate ridge, between this ridge and the dorsal umbo the hinge platform is transversely striated, this area presumably serving for the attachment of the diductor muscles. Median septum thin with a rounded free edge, extending to a point approximately one-third the total length of the valve from its posterior tip, low posteriorly, gradually increasing in height anteriorly and terminating abruptly. Loop with crura short, fairly stout, rounded; crural processes tapering to low points directed medially; descending branches wide with short thorn-shaped processes scattered along the anterior halves of their laterally-directed free edges, midway along their length attached to the anterior crest of the median septum by moderately wide lateral connecting bands; ascending branches and transverse band lamellar and wide, the postero-lateral corners of the transverse band extended by a a pair of tapering flanges which are continuous dorsally with a pair of thick connecting bands running to the anterior crest of the septum; thick longitudinal ridges mark the surface of the transverse band and extend from its anterior border to the posterior borders of the flanges.

Ventral interior with small, moderately thick hinge teeth, subcircular in outline. Dental plates lamellar, confluent with the bases of the hinge teeth and descending to the floor of the valve thus delimiting two small lateral cavities; dorsally and posteriorly confluent with a wide, impunctate sheath, the sessile pedicle collar.

TYPE MATERIAL: Five syntypes T901A-E in the Ralph Tate Collection, South Australian Museum, of which T901A (length 11 mm, breadth 11 mm, depth 5 mm) is selected as the lectotype.

TYPE LOCALITY: *Freestone Cove Sandstone*: Table Cape, Tasmania (Lower Miocene).

Paraldingia tepperi (Tate 1880)
(Pl. 6, fig. 11-14)

Terebratella tepperi Tate 1880, *Trans. R. Soc. S. Aust.* 3: 160, Pl. 9, figs. 8a-c.

? *Terebratella tepperi* Thomson 1927, *N.Z. Board Sci. & Art*, Manual No. 7: 293.

DESCRIPTION: Shell outline subcircular, greatest width lying at mid-length; unequally biconvex, the dorsal valve moderately and evenly convex, ventral valve slightly deeper with a slight median carina over the posterior half of the valve. Anterior and lateral commissures rectimarginate; cardinal margin broad and gently curved. Deltidial plates discrete, small. Palintropes wide, defined by rounded beak ridges. Foramen round, mesothyrid, incomplete, marginate, lined by a sessile pedicle collar. Beak suberect.

The cardinalia of the dorsal valve resemble these structures in *P. woodsii*, the only difference lying in the outline of the anterior border of the hinge plates. This border is straight in *P. tepperi* and medially indented in *P. woodsii*. The loop is broken in the

only dorsal valve of *P. tepperi* observed, however the edges of two pairs of connecting bands are visible on the anterior crest of the septum.

TYPE MATERIAL: Five syntypes T896A-E in the Ralph Tate Collection, South Australian Museum, of which T896C (length 21 mm, breadth 20 mm, depth 11 mm) is selected as the lectotype.

TYPE LOCALITY: *Muloowurtie Clays*: near Ardrossan, Yorke Peninsula, South Australia. (Upper Eocene.)

Paraldingia pentagonalis (Tate 1880)
(Pl. 6, fig. 9, 10)

Terebratella (?) *pentagonalis* Tate 1880, *Trans. R. Soc. S. Aust.* 3: 161, Pl. 9, figs. 5a-b.

(?) *Terebratella* (?) *pentagonalis* Thomson 1927, *N.Z. Board Sci. & Art* Manual No. 7: 293.

DESCRIPTION: Shell outline subpentagonal, the greatest width lying slightly anterior to mid-length; unequally biconvex, the ventral valve deeper, both valves displaying a slight median depression over the anterior halves of their lengths. Anterior and lateral commissures rectimarginate; cardinal margin terebratulid. Beak ridges rounded defining wide palintropes. Deltidial plates discrete, small. Foramen submesothyrid. Beak short, erect.

TYPE MATERIAL: Holotype T883 (length 17 mm, breadth 13 mm, depth 9 mm) in the Ralph Tate Collection, South Australian Museum.

TYPE LOCALITY: *Tortachilla Limestone*: Maslin Bay, Aldinga, South Australia.

STRATIGRAPHIC RANGE: Aldingan (Upper Eocene).

COMMENTS: Tate erected the species *pentagonalis* from two specimens, only one of which is preserved in his Collection. This species bears a close external resemblance to *P. woodsii* and on this basis is referred to the genus. The two species possess a submesothyrid foramen, discrete deltidial plates and a terebratulid cardinal margin. They differ in the degree of convexity of the valves and in folding. *P. woodsii* displays a sulcate anterior commissure and slightly convex valves with a pronounced carina and sulcus in the ventral and dorsal valves respectively. *P. pentagonalis* is moderately and evenly biconvex with a rectimarginate anterior commissure.

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EXPLANATION OF PLATES

PLATE 5

Frenulina pumila (Tate)

FIG. 1-3—Dorsal, anterior and lateral views of P17236 (National Museum of Victoria) neotype, × 3.
FIG. 4—Ventral valve interior, × 3.
FIG. 5—Dorsal valve interior showing loop. One of the dental plates is visible projecting from the top left hand corner of the broken ventral valve, × 4.
FIG. 6-8—Dorsal valve interiors showing differences in different specimens in the extent of hinge plates, × 10.
Tambo River Formation, Swan Reach, Victoria.

Aldingia furculifera (Tate)

FIG. 9, 10—Dorsal and lateral views of T895H (Ralph Tate Collection, South Australian Museum), lectotype, × 1½.
FIG. 11—Dorsal valve interior, × 5.
FIG. 12—Anterior view of dorsal valve interior, × 5.
FIG. 13—Anterior view of internal hinge area to show dental plates in young specimen, × 4.
Tortachilla Limestone, Blanche Pt., Aldinga, South Australia.
FIG. 14—Dorsal view of specimen T908A in the Ralph Tate Collection, South Australian Museum, × 1½.
FIG. 15, 16—Respectively dorsal and ventral valve interiors of specimen T908A in the Ralph Tate Collection, South Australian Museum, × 1½.
Blanche Point Marls, Blanche Pt., Aldinga, S.A.
All specimens with the exception of those represented in Figs. 1-3, 14-16, coated with magnesium chloride.

PLATE 6

Kingena mesembrina (Etheridge)

FIG. 1-3—Dorsal valve interior; ventral, lateral and anterior views of hypotype in the collection of the Geology Department, University of Western Australia and figured by Elliott (1952, Pl. 1, fig. 4), × 5.
Gingin Chalk, Western Australia.

Paraldingia woodsii (Tate)

FIG. 4-6—Dorsal valve interior; ventral, lateral and anterior views, × 5.
FIG. 7, 8—Dorsal and lateral views of T901A, lectotype, Ralph Tate Collection, South Australian Museum, × 2½.
Freestone Cove Sandstone, Table Cape, Tasmania.

Paraldingia pentagonalis (Tate)

FIG. 9, 10—Dorsal and lateral views of T883, holotype, Ralph Tate Collection, South Australian Museum, × 2.
Tortachilla Limestone, Maslin Bay, Aldinga, South Australia.

Paraldingia tepperi (Tate)

FIG. 11—Dorsal interior of T896A, syntype, Ralph Tate Collection, South Australian Museum, X 4.
FIG. 12, 13—Dorsal and lateral views of T896C, lectotype, Ralph Tate Collection, South Australian Museum, × 1½.
FIG. 14—Anterior view of ventral interior of T896B, syntype, Ralph Tate Collection, South Australian Museum, × 4.
Muloowurtie Clays, near Ardrossan, Yorke Peninsula, South Australia.

All specimens with the exception of those represented in Fig. 4-6 coated with magnesium oxide.